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Degree-day measurements using an automatic temperature integrator

In studies which attempt to relate plant development to weather, air temperature has often been used as a significant variable. A common technique is to calculate accumulated temperature units above some appropriate base temperature; to monitor the phenological stages of crops such as maize, for example, degree-days above 10°C are summed. The technique assumes that the rate of plant development varies linearly with temperature although this is only true over a limited temperature range. Even so, the 'thermal time' provides a useful developmental index since it pays due regard to both temperature and duration of exposure to each temperature.

Degree-day recordings above or below selected bases have also been used to estimate glasshouse heating losses and ventilation requirements for onion and potato stores.

There are clearly many advantages of an 'on site' instrument for accumulating heat units above (or below) a given base. This memorandum reports some comparisons between degree-day summations registered by such a commercially available instrument with those registered by using daily values of maximum and minimum temperatures to calculate degree-days (as laid down in Met. Office leaflet 10).

Instrumentation

The Edale model DT85 temperature integrator was used. It was originally purchased by the Agronomy Dept. at a cost of £230 during Spring 1981 from Edale Instruments

Limited, Toft, Cambridge, CB 3 7RL (Tel: Comberton 2782).

The DT85 is a portable, compact (200mm x 75mm x 150mm) instrument for integrating temperatures in the range -30 to +50°C with time. A threshold temperature can be selected in one degree steps over the range and results are displayed on a resetable, four digit counter in units of Day °C. It is a battery-powered unit (requiring 6 AA size cells) and will operate unattended for several weeks, a battery test facility being incorporated to show remaining battery life. A mains power pack is provided as an optional extra.

The instrument has two probes (which can be chosen for use with solids, liquids or gases as required), the instrument integrating the temperature difference between the two points. Three 'modes' of operation are allowed:

(i) 'differential' mode - both probes are sensed and the difference in temperature between the two probes is integrated.

(ii) 'A' mode - when integration above a fixed temperature is required; only one probe is used. The fixed baseline temperature is -30°C.

(iii) 'B' mode - using one probe to integrate below a fixed base. The fixed ceiling temperature is 50°C.

In all modes, the threshold set indicates the number of degrees centigrade which the temperature difference between the two points must exceed before integration occurs. With the threshold set at 20°C, for example, each mode is affected as follows:

'Diff' - temperature difference between two probes in excess of 20°C is integrated.

'A' - temperature above -10°C is integrated (ie. -30 + 20°C)

'B' - temperature below 30°C is integrated (ie. +50 - 20°C)

Two further points are perhaps worth mentioning. Firstly the integrator case is not weatherproof and should be enclosed in a polythene bag if the instrument is to be exposed to damp or wet conditions. Secondly, the integrator should be protected against long periods of exposure to direct sunlight as this may cause overheating and thus loss of accuracy.

Method

The temperature integrator was erected in a large Stevenson screen within the met. enclosure* at Coley Park. A single, 'general-purpose' probe was allowed to hang freely within the screen in close proximity to the maximum and minimum thermometers.

Accumulated temperatures above 10°C were recorded over the period 11 May - 31 October 1981. The instrument was read daily as part of the 0900 GMT observation except at weekends when the accumulative total for the weekend was read on Monday mornings.

Daily readings of maximum and minimum temperature were used to calculate degree-days above 10°C as a comparison; weekend temperature values were estimated from thermograph charts.

Results

A comparison between instrument readings and daily degree-day summations is given in Table 1. Unfortunately several comparisons were lost through battery failure occurring over weekends - the number of missing observations during each month are shown in the table. The last line shows the actual difference evaluated from days on which actual maximum and minimum thermometer readings were taken.

* The met-site was established during 1979 to provide met. information to MAFF departments who had expressed interest in 'on-site' weather records (eg. Agronomy). It is not an official site and therefore does not submit monthly returns to Bracknell.

Table 1

Comparison between temperature integrator and degree-days calculated from daily maxima and minima during 1981

	May	Jun	Jul	Aug	Sep	Oct	Total
Temperature integrator (T)	54.0	115.0	200.0	224.0	164.0	27.0	784.0
Daily dd (D)	56.2	112.6	179.1	213.0	157.4	35.7	754.0
Difference (T-D)	-2.2	2.4	20.9	11.0	6.6	-8.7	30.0
No. missing values	11	3	2	2	0	2	
Actual difference (T-D)	-2.3	-0.9	0.7	0.7	-0.6	-4.5	-6.9
(number of readings)	(6)	(12)	(9)	(7)	(13)	(10)	

The % difference* between the two sets of values over the whole period was 3.8%.

Discussion

The instrument manufacturers claim the measurement accuracy of the DT85 to be within 2% over an ambient temperature range of 0-40°C, although no mention is made of how this figure was derived. This claim compares favourably with the average error of ± 4% found in this study, especially when one considers that the daily dd comparative values are themselves open to error (See ag. mem 916).

The inclusion of thermograph temperatures was necessary over weekends which tended to be a poor substitute for the thermometer readings. This is illustrated by a reduction in the average May - October % difference from 3.8 to 2.4% (ignoring sign) when considering only those readings for which actual max. and min. thermometer observations were available (57 occasions).

* % difference $= \frac{(T - D)}{(T)} \times 100$

It is unfortunate that 'actual' hourly dd values could not be used to ascertain the true accuracy of the instrument but nevertheless, from this small trial, the manufacturers claim of 2% accuracy appears feasible.

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Please refer any comments and suggestions to the author.

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